REMARKS

The objection to the Amendment of August 27, 2004, and rejection under 35 USC 112 are because the Examiner states that the original disclosure does not support for the electrode layers being continuous. We respectfully disagree. The specification page 10, lines 16-18, discloses that the electrode layer can be made of for example aluminium foil. Further, figure 7 and the specification related thereto show that in the strip the electrode layers are continuous. Further, Figure 7 and the specification disclose how a pipe is made by winding the strip spirally into a pipe, such that the adjacent convolutions in the strip touch each other. Thus, figure 7 and the specification together disclose how the pipe has continuous electrode layers.

The Examiner rejected claim 1 as being anticipated by Nishino (US 6,089,278). The Examiner states that the adhesive layer of Nishino is inherently an insulating layer. The reason for his statement is that the adhesive layer of Nishino is made of plastic, and the Examiner is of the opinion that inherently plastic material is an insulator when not provided with conductive materials therein. We respectfully disagree. It is known to a person skilled in the art that some of the plastics are conductive, although they are not provided with additives to make them conductive. The attached enclosures show examples of inherently conductive plastics. For example polypyrrole and polyaniline are inherently conductive polymers. Thus there is no disclosure of the claimed electrically insulating layer in the Nishino, et al. patent.

The Examiner further rejected claims 1 and 2 as being unpatentable over Brown (US 4,554,650) in view of Schmidt (US 2,691,698). As it has been earlier discussed, brown does not disclose continuous electrode layers. The Examiner states that Schmidt teaches total coverage and such is considered the equivalent of continuous. We strongly disagree. Schmidt

does not disclose a continuous electrode. Schmidt discloses on column 10, lines 10-14 that the aluminium foil wrap 5 is applied such that the laps or adjacent convolutions are spaced so that they do not touch or overlap. This means that, for example, a nail can penetrate into the cable from between the adjacent aluminium foil wraps, such that it does not touch the aluminium foil 5.

Further, the Examiner states that the layers in Schmidt are hollow and provided with wires. It is really astonishing that the cable disclosed by Schmidt can be regarded as a hollow pipe. Attached is a page from the new Oxford Dictionary of English, which describes that a hollow article has an empty space inside. Because the layer 2 in Schmidt is wrapped around wires, the layers 2, 3, 4, 5 and 6 are not hollow, because there is not an empty space inside. A telephone interview with the Examiner is requested to ask by which terms he would describe a hollow pipe such that everybody would understand that a hollow pipe does not mean a cable. An Applicant Initiated Interview Request From is attached.

Respectfully submitted,

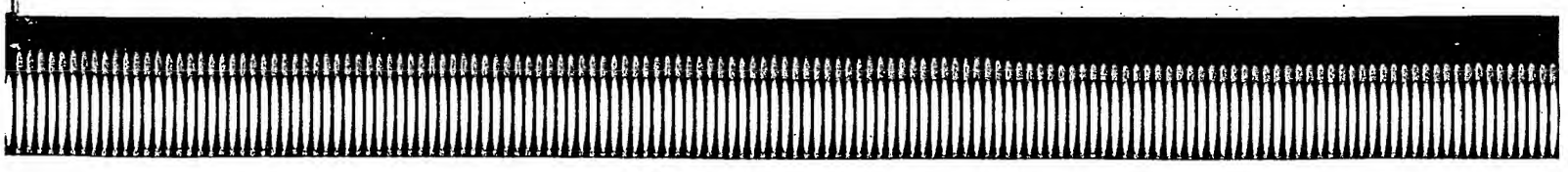
William R. Evans
c/o Ladas & Parry LLP
26 West 61st Street
New York, New York 10023
Reg. No. 25858
Tel. No. (212) 708-1930

The New Oxford Dictionary of English

EDITED BY
Judy Pearsall

CHIEF EDITOR, CURRENT ENGLISH DICTIONARIES
Patrick Hanks

CLARENDON PRESS · OXFORD
1998



consisting of a metal cylinder with a toothed edge.

Holi /'həʊliː/ ▶ noun a Hindu spring festival celebrated in February or March in honour of Krishna.
– ORIGIN via Hindi from Sanskrit *holi*.

Holiday /'hɒlɪdeɪ/, Billie (1915–59), American jazz singer; born *Eleanora Fagan*. She began her recording career with Benny Goodman's band in 1933, going on to perform with many small jazz groups.

holiday chiefly Brit. ▶ noun (often **holidays**) an extended period of recreation, especially one spent away from home or in travelling: *I spent my summer holidays on a farm* | *Fred was on holiday in Spain.*
■ a day of festivity or recreation when no work is done: *25 December is an official public holiday.* ■ [as modifier] characteristic of a holiday; festive: *a holiday atmosphere.*
▶ verb [no obj., with adverbial of place] spend a holiday in a specified place: *he is holidaying in Italy.*
– ORIGIN Old English *hāligdæg* 'holy day'.

holiday camp ▶ noun Brit. a site for holidaymakers with accommodation, entertainment, and leisure facilities.

holidaymaker ▶ noun Brit. a person on holiday away from home.

holiday season ▶ noun (in the US) the period of time from Thanksgiving until New Year, including such religious festivals as Christmas, Hanukkah, and Kwanzaa.

holiday village ▶ noun Brit. a large, modern holiday camp.

holier-than-thou ▶ adjective characterized by an attitude of moral superiority: *they had quite a critical, holier-than-thou approach.*

holiness ▶ noun [mass noun] the state of being holy: *life of holiness and total devotion to God.*
■ **(His/Your Holiness)** a title given to the Pope, Orthodox patriarchs, and the Dalai Lama, or used in addressing them. ■ [as modifier] denoting a Christian renewal movement originating in the mid 19th century among Methodists in the US, emphasizing the Wesleyan doctrine of the sanctification of believers.
– ORIGIN Old English *hālignes* (see **HOLY**, **-NESS**).

Holinshed /'hɒlɪnʃɛd/, Raphael (died c1580), English chronicler. Although the named compiler of *The Chronicles of England, Scotland, and Ireland* (1577), Holinshed wrote only the *Historie of England* and had help with the remainder. The revised (1587) edition was used by Shakespeare.

holism /'həʊlɪz(ə)m, 'hɒl-/ ▶ noun [mass noun] Philosophy the theory that parts of a whole have such intimate interconnection, such that they cannot exist independently of the whole, or cannot be understood without reference to the whole. The whole is thus regarded as greater than the sum of its parts. Holism is often applied to mental states, language, and ecology. The opposite of **ATOMISM**.
■ Medicine the treating of the whole person, taking account mental and social factors, rather than just the symptoms of a disease.
– DERIVATIVES **holist** adjective & noun.
– ORIGIN 1920s: from **HOLO-** 'whole' + **-ISM**; coined by J. C. Smuts to designate the tendency in nature to produce organized 'wholes' (bodies or organisms) from the ordered grouping of units.

holistic /həʊ'lɪstɪk, hɒ-/ ▶ adjective chiefly Medicine characterized by understanding the whole of something to be intimately interconnected and explicable only by reference to the whole.
■ Medicine characterized by the treatment of the whole person, taking into account mental and social factors, rather than just the symptoms of a disease.
– DERIVATIVES **holistically** adverb.

holla /'hɒlə/ ▶ exclamation archaic used to call attention to something: *'Holla! what storm is this?'*
– ORIGIN early 16th cent. (as an order to cease): from French *holà*, from *ho* 'hoa' + *là* 'there'.

Holland another name for the **NETHERLANDS**.
■ a former province of the Netherlands, comprising the coastal parts of the country. It is now divided into **North Holland** and **South Holland**.

holland ▶ noun [mass noun] a kind of smooth linen fabric, used chiefly for wearing blinds and furniture covering.
– ORIGIN Middle English: from **HOLLAND** (the name of a former province of the Netherlands).

cloth was made, from Dutch, earlier *Holtlant* (from *holt* 'wood' + *-lant* 'land').

hollandaise sauce /ˌhɒlən'deɪz, 'hɒlən deɪz/ ▶ noun [mass noun] a creamy sauce of melted butter, egg yolks, and vinegar, served especially with fish.
– ORIGIN French *hollandaise*, feminine of *hollandais* 'Dutch', from *Hollande* 'Holland'.

Hollander ▶ noun dated a native of the Netherlands.

Hollands ▶ noun [mass noun] archaic Dutch gin.
– ORIGIN from archaic Dutch *hollandsch genever* (earlier form of *hollands jenever*) 'Dutch gin'.

holler informal ▶ verb [no obj.] (of a person) give a loud shout or cry: *he hollers when he wants feeding* | [with direct speech] *'I can't get down,' she hollered.*
▶ noun a loud cry or shout.
■ (also **field holler**) chiefly US a melodic cry with abrupt or swooping changes of pitch, used originally by black slaves at work in the fields and later contributing to the development of the blues.
– ORIGIN late 17th cent. (as a verb): variant of the rare verb *hollo*; related to **HALLOO**.

Hollerith /'hɒlərɪθ/, Herman (1860–1929), American engineer. He invented a tabulating machine using punched cards for computation, an important precursor of the electronic computer, and founded a company that later expanded to become the IBM Corporation.

hollow ▶ adjective **1** having a hole or empty space inside: *each fibre has a hollow core.*
■ having a depression in its surface; concave: *hollow cheeks.* ■ (of a sound) echoing, as though made in or on an empty container: *a hollow cough.*
2 without significance: *the result was a hollow victory.*
■ insincere: *a hollow promise.*
▶ noun a hole or depression in something: *a hollow at the base of a large tree.*
■ a hole or enclosed space within something: *he held them in the hollow of his hand.* ■ a small valley: *a village nestled in a hollow in the Cotswolds.*
▶ verb [with obj.] form by making a hole: *a tunnel was hollowed out in a mountain range.*
■ make a depression in: *Flora's laugh hollowed her cheeks.*
– PHRASES **beat someone hollow** defeat or surpass someone completely or thoroughly.
– DERIVATIVES **hollowly** adverb, **hollowness** noun.
– ORIGIN Old English *holh* 'cave'; obscurely related to **HOLE**.

hollow-eyed ▶ adjective (of a person) having deeply sunk eyes, typically as a result of illness or tiredness.

hollow-hearted ▶ adjective archaic insincere; false.

hollow square ▶ noun historical a body of infantry drawn up in a square with a space in the middle.

hollowware ▶ noun [mass noun] hollow articles of cookware or crockery, such as pots, kettles, and dishes.

Holly, Buddy (1936–59), American rock-and-roll singer, guitarist, and songwriter; born *Charles Hardin Holley*. He recorded such hits as 'That'll be the Day' with his band, The Crickets, before going solo. He was killed in an aircraft crash.

holly ▶ noun a widely distributed evergreen shrub, typically having prickly dark green leaves, small white flowers, and red berries.
• Genus *Ilex*, family Aquifoliaceae: many species, in particular *I. aquifolium*, the common holly of Europe.
■ the branches, foliage, and berries of this plant, used in decorations at Christmas.
– ORIGIN Middle English *holi*, shortened form of Old English *holegn*, of Germanic origin; related to Dutch *hulst* and German *Stechpalme*.

holly fern ▶ noun a small shield fern which has evergreen fronds with a double row of stiff leaflets, found chiefly in mountainous regions of both Eurasia and North America.
• Genus *Polystichum*, family Dryopteridaceae: in particular the widespread *P. lonchitis*.

hollyhock ▶ noun a tall Eurasian plant of the mallow family, with large showy flowers.
• *Alcea rosea*, family Malvaceae.
– ORIGIN Middle English: from **HOLY** + obsolete *hock* 'mallow', of unknown origin. It originally denoted the marsh mallow, which has medicinal uses (perhaps from a use of 'holy'); the current sense dates from the mid 16th cent.

holm oak ▶ noun the holm oak or the kermes oak, a tough evergreen leaves that are

Hollywood a district of Los Angeles, the principal centre of the American film industry.
■ the American film industry and the lifestyles of the people associated with it: *he was never seduced by the glitz and money of Hollywood.*

holm /həʊm/ (also **holme**) ▶ noun Brit. an islet, especially in a river or near a mainland.
■ a piece of flat ground by a river, which is submerged in time of flood.
– ORIGIN Old English, from Old Norse *holmr*; more frequently used in Scotland and northern England, but found in place names throughout Britain.

Holmes¹ /həʊmz/, Arthur (1890–1965), English geologist and geophysicist. He pioneered the isotopic dating of rocks and was one of the first supporters of the theory of continental drift. His *Principles of Physical Geology* (1944) became a standard text.

Holmes² /həʊmz/, Oliver Wendell (1809–94), American physician, poet, and essayist. His best-known literary works are the humorous essays known as 'table talks', which began with *The Autocrat of the Breakfast Table* (1857–8).

Holmes³ /həʊmz/, Sherlock, an extremely perceptive private detective in stories by Sir Arthur Conan Doyle.
– DERIVATIVES **Holmesian** adjective.

holmium /'hɒlmɪəm/ ▶ noun [mass noun] the chemical element of atomic number 67, a soft silvery-white metal of the lanthanide series. (Symbol: **Ho**)
– ORIGIN late 19th cent.: modern Latin, from *Holmia*, Latinized form of *Stockholm*, the capital of Sweden (because many minerals of the yttrium group, to which holmium belongs, are found in that area); discovered by P.T. Cleve, Swedish chemist.

holm oak ▶ noun an evergreen southern European oak, which has dark green glossy leaves. Also called **EVERGREEN OAK** or **ILEX**.
• *Quercus ilex*, family Fagaceae.
– ORIGIN late Middle English: *holm*, alteration of dialect *hollin*, from Old English *holen* 'holly'.

holo /'hɒləʊ/ ▶ noun (pl. **-os**) informal a hologram.

holo- ▶ combining form whole; complete: *holocaust* | *holophytic.*
– ORIGIN from Greek *holos* 'whole'.

holocaust /'hɒləkɔːst/ ▶ noun **1** destruction or slaughter on a mass scale, especially caused by fire or nuclear war: *a nuclear holocaust* | [mass noun] *the threat of imminent holocaust.*
■ **(the Holocaust)** the mass murder of Jews under the German Nazi regime during the period 1941–45. More than 6 million European Jews, as well as members of other persecuted groups, were murdered at concentration camps such as Auschwitz.
2 historical a Jewish sacrificial offering which is burnt completely on an altar.
– ORIGIN Middle English: from Old French *holocauste*, via late Latin from Greek *holokauston*, from *holos* 'whole' + *kaustos* 'burnt' (from *katein* 'burn').

Holocene /'hɒləsiːn/ ▶ adjective Geology of, relating to, or denoting the present epoch, which is the second epoch in the Quaternary period and followed the Pleistocene. Also called **RECENT**.
■ [as noun **the Holocene**] the Holocene epoch or the system of deposits laid down during this time.

The Holocene epoch has lasted from about 10,000 years ago to the present day. It covers the period since the ice retreated after the last glaciation and it is sometimes regarded as just an another interglacial period.

– ORIGIN late 19th cent.: coined in French from **HOLO-** 'whole' + Greek *kainos* 'new'.

holoenzyme /ˌhɒləʊ'enzʌɪm/ ▶ noun Biochemistry a biochemically active compound formed by the combination of an enzyme with a coenzyme.

Holofernes /ˌhɒlə'fɜːniːz, hə'lɒfəˌniːz/ (in the Apocrypha) the Assyrian general of Nebuchadnezzar's forces, who was killed by Judith (Judith 4:1 ff.).

hologram /'hɒləgram/ ▶ noun a three-dimensional image formed by the interference of light beams from a laser or other coherent light source.
■ a photograph of an interference pattern which, when suitably illuminated, produces a three-dimensional image.

holograph /'hɒlɡrɑːf/ ▶ noun a manuscript handwritten by the person named as its author.
– ORIGIN early 17th cent.: from French *holographe*, or

via late Latin from G
'whole' + *-graphos* 'writ

holography /hɒ'lɒgrə
or production of holog
– DERIVATIVES **hologr**
ically adverb.

holophrasis /ˌhɒlə(ʊ)'
expression of a whole
example *howdy* for *how*
■ the learning of linguis
by very young chil
language, for example
– DERIVATIVES **holoph**
adjective.

holophytic /ˌhɒlə(ʊ)'fi
plant or protozoan) a
organic compounds by

holothurian /ˌhɒlə(ʊ)'θ
cucumber.
– ORIGIN mid 19th cen
genus name *Holothuria*
denoting a kind of zoo

Holothuroidea /ˌhɒlə
of echinoderms that co
– DERIVATIVES **holothur**
adjective.
– ORIGIN modern Latin
holothourion (see **HOLOTH**

holotype /'hɒlətʌɪp/ ▶ n
type specimen upon w
name of a new specie
SYNTYPE.

hols ▶ plural noun Brit. infor
– ORIGIN early 20th cent.:

Holst /hɒlst/, Gustav
English composer, of Sw
He made his reputation
The Planets (1914–16). O
Hymns from the Rig Veda (

Holstein¹ /'hɒlstʌɪn, -ʃtʌ
German kingdom of
southern part of the Jutl
Denmark from 1474, it w
and incorporated with t
Schleswig as the provinc

Holstein² /'hɒlstʌɪn, -iːn
typically black-and-whi
cattle.

Holsteinian /hɒl'stʌɪnɪ
relating to, or denoting
the Pleistocene in north
Elster glaciation and corr
in Britain.
■ [as noun **the Holsteinian**]
or the system of deposits
– ORIGIN 1960s: from **HOL**

holster /'həʊlstə, 'hɒl-/ ▶
a handgun or other fir
leather and worn on a
shoulder holster.
▶ verb [with obj.] put (a gun) in
– ORIGIN mid 17th cent.
contemporary with Dut
origin.

holt¹ /həʊlt/ ▶ noun **1** the d
2 dialect, chiefly US a grip or
– ORIGIN late Middle Engli
HOLD¹.

holt² /həʊlt/ ▶ noun archaic o
hill.
– ORIGIN Old English, of Ge
Middle Dutch *hout* and Ge
European root shared by

holus-bolus /ˌhəʊləs'bəʊ
archaic all at once: *swallow*
made holus-bolus.
– ORIGIN mid 19th cent. (or
pseudo-Latin for 'whole bo

holy ▶ adjective (**holier**, **h**
consecrated to God or a r
the Holy Bible | *the holy mont*
■ (of a person) devoted to the
holy men. ■ morally and sp
lead a holy life.
2 dated or humorous used in e
or dismay: *holy smoke!*
– ORIGIN Old English *hāli*
related to Dutch and Germ

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ElectroActive Polymers - EAPs

Topics Covered

Background

In the last decade a new breed of polymer has emerged which responds to external electrical stimulation by displaying a significant shape or size displacement. These materials, known as electroactive polymers, or more commonly EAPs are now on the verge of many exciting applications.

EAPs have attracted much attention from engineers and scientists from diverse disciplines. In particular, researchers in the field of biomimetics (a field of study where robotic mechanisms are based on biologically-inspired models) find it foreseeable that these materials may be applied to mimic the movements of animals, insects and even human body parts (Figure 1).

Figure 1. Potential application for EAP in biomimetics.

Technologies Sought / Collaborative Research Opportunity

Generally, EAPs have the ability to induce strains that are as high as two orders of magnitude greater than the movements possible with rigid and fragile electroactive ceramics (EACs). EAP materials have higher response speeds, lower densities and improved resilience when compared to shape memory alloys (SMAs). Limiting factors to EAPs are low actuation forces, mechanical energy density and lack of robustness. However, there have been reported successful applications in catheter steering elements, miniature manipulators, dust-wipers, miniature robotic arms and grippers.

There are two major categories that EAPs depending on their mode of activation mechanism, these include, electronic and ionic categories. Table 1, outlines the advantages and disadvantages of both types of EAPs.

Table 1. Outline advantages and disadvantages of both electronic and ionic EAP categories.

EAP Type	Advantage	Disadvantage
Electronic EAP	• Can operate in room conditions for long periods of time • Rapid response time (mSec levels) • Can hold strains under DC activation • Induces relatively large actuation forces	• Requires high voltages (~150 MV/m) • Requires compromise between strain and stress • Glass transition temperature is inadequate for low temperature actuation tasks
Ionic EAP	• Requires low voltage • Provides predominately bending actuation (longitudinal mechanisms can be constructed) • Exhibits large	Except for CP (Conductive Polymers), ionic EAPs don't hold strain under DC voltage • Slow response

	bending displacements	(fraction of a second) • Bending EAPs induce a relatively low actuation force • Except for CP and CNT (Carbon Nanotubes), it is difficult to produce a consistent material (particularly IPMC – Ionomeric Polymer-Metal Composites) • In aqueous systems the material sustains hydrolysis at > 1.23 V

Electric field or Coulomb forces generally drive electronic EAPs, while the primary driver for ionic EAPs is the mobility or diffusion of ions.

Types of Electric EAPs and Ionic EAPs are summarised below:

Electric EAPs

Ferroelectric Polymers

Piezoelectricity was discovered in 1880, with the discovery that certain crystals e.g. quartz, tourmaline and Rochelle salt, when compressed along certain axes, produced a voltage on the surface of the crystal. The reverse effect was also found whereby application of an electric current saw the crystal sustain an elongation.

Poly(vinylidene fluoride) or PVDF and its copolymers are the most exploited ferroelectric polymers. They consist of a partially crystalline component in an inactive amorphus phase. Large applied AC fields (~200 MV/m) induce electrostrictive (non-

linear) strains of nearly ~2%. P(VDF-TrFE) a PVDF polymer which has been subject to electron radiation has shown electrostrictive strain as high as 5% at lower frequency drive fields (150 V/μm).

Ferroelectric EAP polymer actuators can be operated in air, vacuum or water and throughout a wide temperature range.

Dielectric EAP

Electrostatic fields can be employed to those polymers exhibiting low elastic stiffness and high dielectric constants to induce large actuation strain, these polymers are known as electro-statically stricted polymers (ESSP) actuators.

Dielectric EAP actuators require large electric fields (~100 V/μm) and can produce strain levels (10—200%). It has been reported that an acrylic elastomer tape manufactured by 3M™ (tradename VHB™) is capable of planar strains of more than 300% for biaxially symmetric constraints and linear strains up to 215% for uniaxial constraints.

Electrostrictive Graft Elastomers

This is a polymer consisting of two components, a flexible macromolecule backbone and a grafted polymer that can be produced in a crystalline form. The material exhibits high electric field induced strain (~4%) combined with mechanical power and excellent processability.

A typical example is a combination of an electrostrictive-grafted elastomer with a piezoelectric poly(vinylidene fluoride-trifluoro-ethylene) copolymer. This combination has the ability to produce a varied amount of ferroelectric-electrostrictive molecular composite systems. These may be operated as a piezoelectric sensor or even an electrostrictive actuator.

Electrostrictive Paper

Generally the paper is composed of a multitude of discrete particles, which are mainly of a fibrous nature forming a network structure. An example of which is silver laminated paper whereby two silver laminated pieces of paper with silver electrodes are placed on the outside surfaces. Upon electric voltage being applied to the electrodes a bending displacement occurs.

These types of actuators are lightweight, simple to fabricate and are likely to be used in applications such as active sound

absorbers, flexible speakers and "smart" shape control devices.

Electro-Viscoelastic Elastomers

These materials are composites of silicone elastomer and a polar phase. Upon curing an electric field is applied that orientates the polar phase within the elastomeric matrix. An applied electric field (<6 V/μm) induces changes in shear modulus.

Typical forecast applications are as alternatives to electro-rheological fluids for active damping applications.

Liquid Crystal Elastomer (LCE) Materials

These posses EAP characteristics by inducing Joule heating. LCEs are composite materials consisting of monodomain nematic liquid crystal elastomers and conductive polymers, which are distributed within their network structure. The actuation mechanism is a phase transition between nematic and isotropic phases. The actuation takes place in less than a second.

Ionic EAPs

Ionic Polymer Gel (IPG)

These are polymer gels having the potential of matching the force and energy density of biological muscles. The polyacrylonitrile materials are activated by chemical reaction (s), a change from an acid to an alkaline environment inducing an actuation through the gel becoming dense or swollen. The actuation is somewhat slow due to the diffusion of ions through the multilayered gel.

Ionomeric Polymer-Metal Composites (IPMC)

These are EAPs that bend in response to an electrical activation as a result of the mobility of cations in the polymer network. Generally, two types of base polymers are employed to form IPMCs these are Nafion® (perfluorosulphonate manufactured by Du Pont) and Flemion® (perfluorocaboxylate manufactured by Asahi Glass, Japan). IPMC require relatively low voltages to stimulate a bending response (1-10 V) with low frequencies below 1 Hz.

Conductive Polymers (CP)

CPs actuate via the reversible counter-ion insertion and expulsion that occurs during redox cycling. Significant volume changes

occur through oxidation and reduction reactions at corresponding electrodes through exchanges of ions with an electrolyte.

Electrodes are commonly fabricated from polypyrrole or polyaniline, or PAN doped with HCl. CP actuators requires voltages in the range of 1-5 V. Variations to the voltage can control actuation speeds. Relatively high mechanical energy densities of over 20 J/cm^3 are attained with these materials, however, they posses low efficiencies at levels of 1%.

Other material combinations for CP are polypyrrole, polyethylenedioxythiophene, poly(p-phenylene vinylene)s, polyaniline and polythiophenes. Some applications reported for these CPs are miniature boxes that have the ability to open and close, micro-robots, surgical tools, surgical robots that assemble other micro-devices.

Carbon Nanotubes (CNT)

In 1999, CNTs emerged as formal EAPs with diamond-like mechanical properties. The actuation mechanism is through an electrolyte medium and the change in bond length via the injection of charges that affect the ionic charge balance between the nano-tube and the electrolyte. The more charges that are injected into the CNT the larger the dimension change.

As a consequence of the mechanical strength and modulus of single CNTs and the achievable actuator displacements, these EAPs can boast the highest work per cycle and generate much higher mechanical stresses than other forms of EAPs

Applications

Applications of EPAs are still in their embryonic stages however, some of these include: parts that will have the ability to mimic insect, animal or even human systems (e.g. human artificial muscles), catheter steering elements, miniature manipulator, dust-wipers, miniature robotic arms, grippers, electro-rheological fluids for active damping, miniature boxes, micro-robots, surgical tools and surgical robots that have the ability to assemble other micro-devices.

Primary author: Dr. Yoseph Bar-Cohen
Source: Electroactive Polymers as Artificial Muscles – Reality and Challenges (2001), Proceedings of the 42nd AIAA Structures, Structures Dynamics and Materials Conferences (SDM), Gossamer Spacecraft Forum (GSF), held in Seattle WA, April 16-19.

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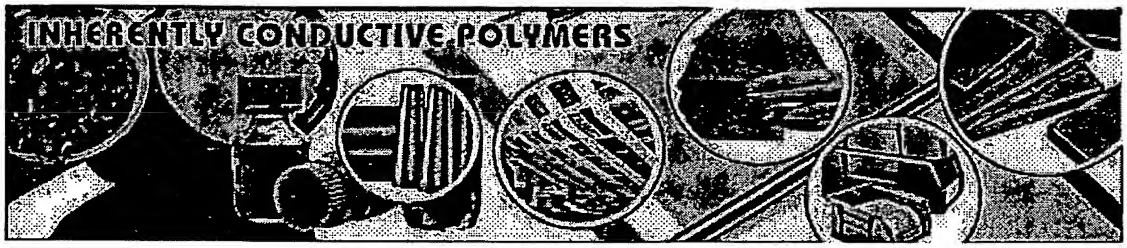
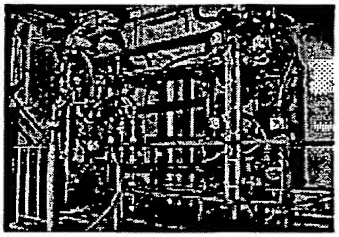


News

Panipol will exhibit at K2004 Fair in October. More...

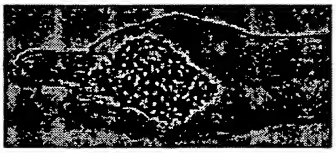
Panipol and Premix enter into co'operation
Panipol oy, the Finnish producer of electrically conductive
Polyaniline polymer and Premix Oy a leader of electrically conductive plastics compound business have reached an agreement on future co-operation. More...

Polyaniline based materials



All Panipol products are based on Inherently Conductive Polymer (ICP) called polyaniline. The inventors of inherently conductive polymers (Dr Heeger, Shirakawa and McDiarmid) received Nobel Prize year 2000 for finding this new class of materials.
The basic building block of polyaniline products –polyaniline emeraldine base (EB)-is now produced in large quantities with Panipol's new patented reactor. This new reactor represents one of the many steps Panipol Ltd has taken to improve polyaniline's quality, consistency and availability.

Products



Panipol product line consists:
1. Melt processable ICP –Panipol DX masterbatches for dry mixing and Panipol CX for compounding
2. Panipol coating systems and inks
3. Panipol polyaniline non-conductive emeraldine base form as well as conductive polyaniline salt (both dry powders).
More...

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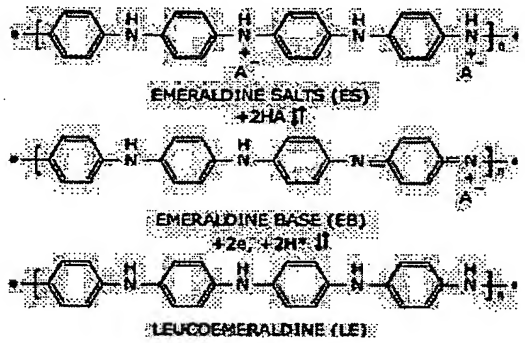
Polyaniline EB

Product and applications

Polyaniline has several non-conductive oxidation states. The most stable of those is emeraldine base (EB), having equal amounts of reduced and oxidized repeating units (figure 1).



The fully oxidized form is pernigraniline and fully reduced form is leucoemeraldine. Doping emeraldine base with acid (dopant) results to a conductive emeraldine salt (ES). This product is called Panipol F.

The polyaniline PA (polyaniline EB) is the basic building block of Panipol's polyaniline products. Panipol has developed a new type of patented process equipment in order to achieve better controllable and consistent polyaniline quality. In industrial practice, polymerization is typically carried out in stirred tanks. However Panipol have selected more favorable flow patterns for polyaniline reaction kinetics and thermodynamics and thus the aniline polymerization results have been improved.

- Effective mixing in Panipol's reactor results in more uniform concentration distribution than what is possible in an industrial scale stirred tank.
- Better concentration and temperature distributions achieved with the new reactor lead to more controlled conditions with less by-products and side-reactions.
- Reactor gives possibilities to several feed points of reactants as well as different conditions (e.g. temperatures) in different parts of the reactor. This possibility, together with accurate knowledge of kinetics and thermodynamics, can be utilized to adjust the yield and selectivity.
- With narrow range of conditions, narrow distribution of polymer properties can be obtained. Moreover, operation conditions of the reactor are often relatively easy to change to produce polymers with different properties.

Repeated polymerization runs have shown that measured and analyzed values such as for example amount of insolubles show constantly very low values < 0.5 % (Average 0.3 %). Molecular weight, particle sizes etc can be also controlled with running parameters. (Figure 1)

Figure 1 on left shows the molecular weight changes due to the process parameter adjustments. Figure at right shows customer specification for the insoluble material. Red horizontal line is the specification limit and values well below are the actual measured values of various consequent batches.

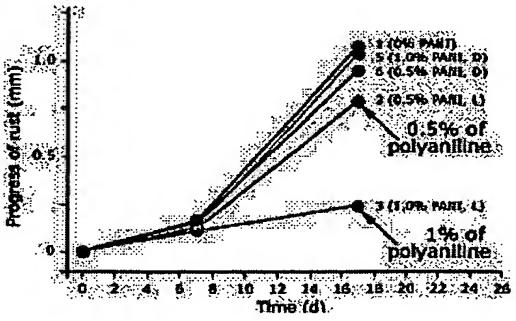
Applications
Panipol Ltd sells polyaniline Emeraldine base as is under the name Panipol PA.

Often in these cases the EB is used in R&D programs aimed to develop new products and formulations.

Panipol PA application example
Panipol has patented an anticorrosion formula. In this formula the Panipol PA is used as a vital ingredient. This formulation is designed to replace the current anticorrosion paints and its main application is shielding steel structures against climatic corrosion.

Formula is based on new homogenous solution method (undoped PA, different from earlier patented methods). Several different independent test methods show that:
- PA improves the anticorrosion properties of coatings even at low dosages (1 – 1.5%)
- The formula is solvent free, environmentally friendly

Immersion Test in 3.5 % NaCl
Progression of rust front (mm) from scratch vs. time
D = dispersion
L = solution
With solution method coating slows rust propagation down remarkably better than with dispersion coating.



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